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# Disinflation Policy and Credibility: The Role of Conventions *

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**Abstract**

This paper studies a simple monetary policy game that allows for multiple equilibria in the private sector's price expectation formation process. The effects of monetary policy then vary with the *convention* that coordinates the expectations of private agents. The role of *credibility* is shown to depend critically on the dominant convention; for instance, a "tough" reputation can be counterproductive if an "opposing" convention is in force. In such a situation, the optimal government policy under precommitment equals the high inflation policy that was the suboptimal Nash-outcome in Barro and Gordon (1983); under discretion, a costly disinflation policy is implemented.

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# 1 Introduction.

The "Rational Expectations Revolution" in macroeconomics has given rise to an extensive literature on the strategic aspects of economic policymaking. Barro and Gordon (1983) [henceforth BG] popularized the game-theoretic analysis of a simple model of monetary policy that was introduced by Kydland and Prescott (1977). In this framework an atomistic private sector, modelled as a single "representative agent", forms a unique rational expectation of the price level such that the government's ex ante optimal zero-inflation policy is not "credible". Some form of *precommitment* is then advantageous to the government, since it makes it possible to lower the rate of inflation without affecting output[1].

Despite the intuitive appeal of this framework, however, the concepts of "credibility" and "reputation" are not unambiguous, and doubts have been raised concerning the robustness of the BG results. In a recent paper, Cubitt (1992) argues that precommitment can be counterproductive if the private sector consists of a single strategic agent, for example a monopolistic labour union, whose preferences differ from the government's.

This paper draws a much stronger conclusion: even if the private sector consists of atomistic agents and shares the objectives of the government, precommitment may be counterproductive. We obtain this result by allowing explicitly for the possibility that a policy game may have multiple equilibria when the private sector consists of a large number of agents. Table 1 confronts the optimal policies of this model with those of the BG model[2].

| | precommitment | discretion |
|---|---|---|
| Barro/Gordon | zero inflation | high inflation ($\pi = \xi/2$) |
| Multiple Equilibria | high inflation, unless initial inflation is lower: $\pi = Min\{\pi_0, \xi/2\lambda\}$ | zero inflation unless output is at full employment level and $\pi_0 < \xi/2\lambda$; $\pi = \pi_0$ otherwise |

Table 1: Optimal Monetary Policy in Alternative Models.

[1] This idea was first expressed by Fellner (1976): if private agents believe the government's announcement of a disinflationary policy they will adjust their inflationary expectations, so that a credible disinflation has a stronger effect on prices and a less negative effect on output and unemployment than a non-credible one. Subsequent authors have by and large adopted the BG framework, focusing on the role of a policymaker's "reputation" as a credible precommitment device. For a comprehensive survey of the literature, see Blackburn and Christensen (1989), or Persson and Tabellini (1990).

[2] In this table $\pi$ represents the rate of inflation, $\xi$ is the weight given to output relative to inflation in the policymaker's objective function, and $\lambda$ is the discount factor.

Our aim is twofold: first, to question the standard concept of credibility, which we show to be essentially connected to the assumption that there exists a unique optimal government policy. Second, to formulate a new approach to disinflation policy which contradicts the conventional wisdom that a "tough" central bank reputation is always preferable and which offers an alternative explanation of real world disinflation experiences.

It has often been noted that the empirical relevance of the credibility literature has so far been extremely limited[3]. This should not be too surprising since the standard BG framework is based on a simple "Lucas supply" model of monetary policy, that is, on an expectations-augmented Phillips-curve with a unique natural rate of output. The initial findings by Barro (1977) in support of this theory have been contradicted by a significant body of evidence: the consensus view now explicitly rejects the notion that only unanticipated money affects real variables[4]. Moreover, it is increasingly being argued that demand shocks may also have *permanent* effects on output and unemployment[5]. If this is true, the idea of a unique natural rate that is essential to the BG model is erroneous and the ensuing analysis of credibility looses its significance. A more realistic approach will have to accept the possibility of "multiple equilibria".

Such a presence of multiple equilibria is not hard to explain. In the BG model the private sector is modelled as a single "representative agent" whose only role is to form a unique rational expectation of the future price level. There are many examples in economics however, where we would expect an economic agent's rational expectation of a macroeconomic outcome to depend on the expectations of other agents, which in turn will depend on their beliefs about the expectations of other agents. Then there exists an externality in the expectations formation process of the private sector as a whole, which makes it misleading to model this expectation — and the resulting actions — as the outcome of the rational choice of a single "representative agent"[6]. Even if we assume that all aggregation problems can be overcome, the existence of this externality makes that the private sector's rational expectation in equilibrium will be non-unique.

The monetary policy model of this paper takes this expectational externality into account. It is shown below that the standard "Lucas supply" model forms a very special case and that in general the impact of government policy will depend on the *convention* which coordinates private agents' beliefs about future production and prices. Following

[3]See, for example, Blackburn and Christensen.

[4]See Ball, Mankiw and Romer (1988)

[5]See De Long and Summers (1988), who argue that demand shocks affect output asymetrically and consequently reject the natural rate hypothesis. Manning (1992) finds evidence for the existence of multiple equilibria in the British labour market.

[6]If we allow for differences in opinion between private agents it is difficult to see that the representative agent model makes sense at all. For a concise discussion of the problems connected to this model, see Kirman (1992).

Lewis (1967) we define a convention as "a regularity in behaviour that is both expected and self-enforcing: everyone conforms, everyone expects others to conform, and everyone prefers to conform given that everyone else conforms". In game-theory, the role of conventions as a solution to the problem of multiple equilibria in a common interest game has been recognized since the pioneering work by Schelling (1960). A standard "real-world" example concerns driving on the right-hand side of the road rather than driving on the left-hand side: in principle, we are completely indifferent about the side of the road on which we drive, but we clearly prefer everyone to drive on the same side. Once we all drive on the same side we will expect everyone else to keep on driving on that side and will do so ourselves: a convention will have emerged.

What intuition can be offered for the role of conventions in relation to monetary policy?[7] It could be argued that the use of money itself is the outcome of a convention, but for a more down-to-earth example consider the reaction of a representative firm in response to a decrease in aggregate demand. It may not be profitable for an individual firm to lower its prices in response to such a decrease, unless it expects all other firms to lower their prices as well. A single firm in a market with a large number of identical other firms may face a 'kinked' demand curve where due to the presence of search costs incurred by buyers the elasticity of demand may be very low below the prevailing market price, so that a lower price, *ceteris paribus*, will hardly raise the demand for a firm's product. If, in this case, the government is expected to decrease the money supply, thus also decreasing aggregate demand, the effect on prices (and therefore on output) is uncertain: if firms expect other firms to lower their prices, they will lower their own prices as well: however, if they expect price stability, they will keep the price of their own product constant. The impact of economic policy will then depend crucially on the way that agents perceive the behaviour of others. A change in the money supply may affect prices, output, or both, depending on microeconomic incentives and the convention which coordinates private agent's beliefs.

The question of how conventions evolve has been adressed only very recently in the game-theoretic literature[8] and in this paper we will abstract from this important problem and take the different conventions as given. This does not mean that they are completely arbitrary, however. We will compare two conventions: the first ("L") represents the standard "Lucas-supply" framework where there exist a unique "natural rate" of output and only unanticipated money has real effects, the second ("DS") allows explicitly for expected money growth to affect prices, and is subject moreover to a "hysteresis" effect that makes the natural rate history-dependent. It will be argued that this second convention gives in many respects a more realistic description of the workings of a monetary policy than the standard Lucas supply model, and offers an alternative explanation for the disinflation

[7] A first attempt to link conventions to the implementation of monetary policy can be found in Ribbers (1988).

[8] See Young (1992)

experiences of industrialized countries in the 1980s.

The main purpose of the paper is however to question "credibility". The practical significance and interpretation of the concept becomes much less clear if private sector expectations are not uniquely determined, since the optimal credible policy will then depend on the prevailing convention in society. If conventions change as microeconomic incentives change, the policymaker may find itself left with the "wrong" reputation. It is thus much harder to give a rationale for precommitment, when the possibility exists that policy outcomes will be negatively affected.

This problem will be illustrated by comparing disinflation policy under the two different conventions outlined above. It is shown that the optimal credible policy in the standard BG monetary policy framework is counterproductive if the private sector coordinates its beliefs according to the second ("DS") convention. In that case, the government would like to precommit itself to a high inflation policy that equals the BG (suboptimal) Nash-solution; without precommitment, it will have to implement a costly disinflationary policy. These last results are diametrically opposed to the conclusions of BG, as was shown in table 1.

The plan of this paper is as follows: Section 2 develops a simple labour market model which provides the basis for the standard BG model. It is shown that a slight modification of this model (implicitly allowing for the role of investment) completely changes its implications: the impact of government policy will be seen to depend on the convention which coordinates private agents' beliefs. Section 3 shows that under a certain convention, monetary policy credibility as originally defined becomes counterproductive. Section 4 consequently derives the optimal policies under precommitment and under discretion for this convention, and discusses the implications of these results. Section 5 concludes.

# 2 The Model.

## 2.1 The Basic Barro-Gordon Model.

Consider the following standard structure[9]:

$$l_t^d = -\zeta(w_t - p_t) + u_t \tag{1}$$

$$l_t^s = \eta(w_t - p_t) \tag{2}$$

$$l_t = l_t^s = l_t^d \tag{3}$$

$$y_t = \theta l_t \tag{4}$$

[9]See, for example, Blanchard and Fischer (1989, p.518)

$\eta, \zeta > 0; 0 < \theta < 1.$

Here $l^s$, $l^d$, and $l$ represent logs of labour supply, labour demand and actual employment respectively, $y$ is log of output, and $p$ is the log of the price level. Finally, $w$ is the log of the nominal wage, and $u$ is an error term which represents shocks to labour demand, that is, aggregate supply shocks. Constants are ignored for notational simplicity.[10]

This is a full market-clearing model; if $u_t = 0$, all real variables are at their unique *natural rate* level: $(w_t^* - p_t^*) = l_t^* = y_t^* = 0$. However, a short-term role for nominal variables appears if wage contracts are signed before actual production takes place, so that workers agree to supply the amount of labour demanded by firms at a nominal wage $w_t$ specified in advance. Full labour market-clearing is then replaced by expected full market-clearing, so that (3) has to be substituted by:

$$w_t = w_t[w_t | E(l_t^s) = E(l_t^d)]; \qquad l_t = l_t^d \tag{5}$$

Assuming that $E(u_t) = 0$, this gives:

$$w_t = {}_{t-1}p_t^e \tag{6}$$

where ${}_{t-1}p_t^e = E(p_t | I_{t-1})$, the rational expectation of the price level formed one period ahead by the (representative agent) private sector.

Production is then given by:

$$y_t = \zeta\theta(p_t - {}_{t-1}p_t^e) + v_t \tag{7}$$

with $v_t = \theta u_t$; it is assumed that the price level $p_t$ is chosen directly by a monetary policymaker.

Rewriting in terms of inflation, $\pi$, gives the "Lucas supply function":

$$y_t = \zeta\theta(\pi_t - {}_{t-1}\pi_t^e) + v_t \tag{8}$$

Assume that the policymaker has a linear quadratic cost function in $\pi$ and $y$ for each period t:

$$z_t = \pi_t^2 - \xi y_t; \qquad \xi \geq 0 \tag{9}$$

Assume furthermore for simplicity that $v_t = 0$ for all t. The policymaker minimizes the present value of its cost function over a finite number of periods, by choosing a programme $\pi_{t,T} = \{\pi_\tau\}_{\tau=t}^T$ for its policy instrument $\pi_\tau$:

$$\min_{\pi_{\tau,T}} L_t = \sum_{\tau=t}^{T} \lambda^\tau z_\tau \tag{10}$$

[10]The labour demand relationship could be derived in the usual way, by equating marginal cost and marginal revenue, that is, by setting $w_t - p_t = ln\theta + (\theta - 1)l_t$. This would add a constant term $ln\theta/(\theta - 1)$ to equation (1). Although this constant was left out, (1) should still be considered as if derived from profit maximization.

It follows from (2), (8) and (9) that the choice of the optimal policy will depend on the effect that the government's policy instrument (the rate of inflation) has on the private sector's inflationary expectations. As shown by BG, the government's *ex ante optimal policy*, obtained by minimizing (10) under the constraint that ${}_{t-1}\pi_t^e = \pi_t$, equals ${}_{t-1}\pi_t^c = \pi_t = 0$, so that $L_t = 0$ for all t.

However, since Kydland and Prescott (1977) it has been well-known that this solution is *time inconsistent* if the government is not able to precommit itself. The interaction between government and the private sector can be modelled as a finetely repeated game under complete information that has a unique subgame perfect solution under discretion. It follows that:

$${}_{t-1}\pi_t^c = \zeta\theta\xi/2 = \pi_t$$

is the optimal credible policy under discretion for all t.
The government's discounted costs in this Nash-equilibrium equal:

$$L_t = \sum_{\tau=t}^{T} \lambda^{\tau}(\zeta\theta\xi/2)^2$$

This is clearly inferior to the solution under precommitment, a policy of zero inflation.

BG proceed to show that a Pareto-superior solution may be sustained if this game has an infinite number of time periods, so that the private sector can play reputational trigger-strategies. Subsequent authors, such as Backus and Driffill (1985), Cuckierman and Meltzer (1986), and Basar and Salmon (1989), focused on the strategic role of "asymmetric information" in relation to a government's reputation. In this paper we will not consider such reputational issues and analyze the effects of monetary policy in a finite-period framework with complete information.

## 2.2 An extended model with atomistic agents.

The model above assumed that employment decisions are taken one period in advance but that the market-clearing value for the real wage is unique and hence has a unique rational expectation. This is a logical consequence of the "representative agent" model where the single representative firm does not face uncertainty about market-clearing since its own supply creates demand in the most direct sense. Suppose now that there exist a one-period lag in production:

$$y_t = \theta l_{t-1}; \qquad 0 < \theta < 1 \tag{11}$$

Because production takes time, the labour hiring decision is linked to an investment decision: a firm has to decide whether to respond to expected changes in output solely by

changing its demand for labour or by adjusting its capital stock as well. If the economy is still assumed to consist of one single firm, this introduction of capital has no consequences at all for the working of the model of section 2.1. Since the 'natural rate' of output reflects the fundamentals of the economy, that is, the state of the technology combined with the relative scarcity of capital and labour, there is no incentive to invest or disinvest unless these fundamentals change. Short-term fluctuations in demand only affect labour demand, and since there still exists a unique natural rate of output and employment only unanticipated monetary policy can have real effects.

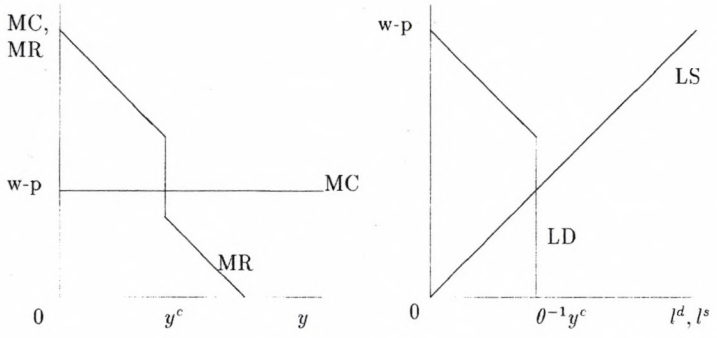
Suppose however that the economy consists of a large number of atomistic firms. In this case the investment decision of an individual firm no longer takes place in the certainty that the fundamentals of the economy are constant. Other firms may have invested or disinvested, thus changing the productive capacity of the economy. As a result there exists an externality in the investment decision of the private sector: the amount of investment an individual firm undertakes will depend on the amount of investment by other firms. Hence there is no unique 'natural rate' of output, employment and the real wage. The private sector has to form expectations with regard to both future production and future prices. This "investment externality" is reflected in the equation for labour demand which replaces equation (1):[11]

$$l_t^d = min\{(\frac{1}{\theta}\,{}_t y_{t+1}^e), (-\zeta\theta(w_t - p_t))\} \qquad \zeta > 0 \tag{12}$$

where ${}_t y_{t+1}^e$ represents the expectations of future production formed in the current period. The firm will expect the market-clearing level of output, or less if the consensus view that a lower level will prevail holds.

The actual investment decision remains implicit in this argument, but the shape of equation (12) reflects a situation in which firms face a potentially 'kinked' demand curve. The willingness of an individual firm to change prices in response to fluctuations in demand, which in this model are exclusively determined by changes in the money supply, will then depend on how it perceives the willingness of other firms to change their prices. Since pricing and production decisions are necessarily linked , one can also express this phenomenon in terms of output: equation (12) in effect states that a firm's investment in future production, through the quantity of labour hired in the current period, depends on the expected level of future production, independently of the level of real wages, as long as the latter are not "too high". This can be understood by considering the shape of an individual firm's marginal cost and marginal revenue curves in figure 1a. The MC curve is simply given by the real wage, the MR curve reflects the presence of search costs on the buyers' side: at the given market price, it does not pay to lower prices (raise output) in reaction to a shift in marginal costs unless one expects others to do so as well.

[11] A similar labour demand equation can be found in Ribbers (1988).




a. Marginal Cost/Marginal Revenue b. Labour Supply & Demand

Figure 1: Multiple Equilibria on the Labour Market

Hence a 'kink' occurs at the expected level of production. There is no unique natural rate of output since the vertical section of the MR line can shift, producing a whole range of equilibria consistent with market-clearing. We will not discuss out-of- equilibrium behaviour here, or the microeconomic interactions between firms which lead to one or another equilibrium. The focus is on the macroeconomic adjustment of labour demand, and it is therefore assumed that some *convention* exists which coordinates individual firms' beliefs on expected output, so that (12) can be considered the labour demand equation of a single "representative" firm. This labour demand curve is shown, together with labour supply, in figure 1b. The vertical part of the curve, representing the first term on the right hand side of (12), gives labour demand when the economy is expected to operate below full employment. This value equals the amount of labour inputs required to produce the expected level of output for the next period and is derived by taking the expectation of (11), the production function. [12] With full employment, labour demand is determined by the second term on the right hand side, which equals equation (1).

We now complete the extended model by adding a standard demand relationship:

$$y_t = m_t - p_t \tag{13}$$

[12] Here it has been assumed that it never pays to operate at excess capacity. Firms take negative shocks to output to be permanent, so that labour hoarding is not profitable. This is a strong assumption which again is self-fulfilling, but it can be justified by referring to the empirical evidence found by De Long and Summers (1988). Moreover, although we will see that it re-enforces our results, leaving it out would not affect the basic conclusions of the model.

This relationship was left out for reasons of simplicity in section 2 — because, in the absence of shocks, choosing the money supply in that model amounts to a direct control of the price level — but it must be included here since the level of production is not uniquely determined.

We assume that the nominal contract wage is still based on an *ex ante* belief in market clearing and thus given by equation (5), which also defines employment as determined by labour demand. However, there is no longer a unique level for the market clearing real wage. Instead, the level of the real wage will depend on the expected level of labour demand, so that instead of $w_t = {}_{t-1}p_t^e$ we can write:

$$w_t = \frac{1}{\eta} E(l_t^d | I_{t-1}) + {}_{t-1}p_t^e \tag{14}$$

The shape of (14) follows from the sequential timing of events in this model. It is assumed that every period starts with the negotiation of the contract nominal wage; the outcome is therefore dependent on information available from the previous period. The policymaker subsequently chooses the money supply, firms then decide on the necessary amount of labour, and finally production takes place. Producers thus have information on current period money supply when they form their expectations about future production and decide how much labour to hire; however, when the nominal wage is specified, this information is not available. This gives rise to a well-known "moral hazard" type of problem: producers may misrepresent their expectations of future production in order to extract concessions from the workers. We will neglect this problem here and assume that wage determination takes place under full knowledge of the convention that rules producers' expectations — though not of the actual expectation, which may depend on current money supply and prices, variables that are unknown at the moment that labour contracts are signed. The precise form of (14), the wage determination equation, will therefore vary with the convention in force.

## 2.3 Conventions.

As should be clear from the preceding discussion, the determination of expectations in this model is both crucial and yet to a large extent still arbitrary. Rational expectation formation would prescribe the expected price level for the current period to depend on all available information at the moment that the expectation is formed, including the structure of the model itself. Hence:

$${}_{t-1}p_t^e = E(p_t | I_{t-1}) = {}_{t-1}m_t^e - {}_{t-1}y_t^e \tag{15}$$

For the moment treating $m_t$ and ${}_{t-1}m_t^e$ as exogenous, this leaves us with the problem of finding ${}_{t-1}y_t^e$. When we attempt to determine which expectation for future output is consistent with the structure of the model we see that the relevant equations, (11) and (12), do

not uniquely determine a rational expectations solution to the model. This indeterminacy of equilibria can be resolved by means of a *convention*, that is, any mechanism that serves to coordinate private agents' expectations on a single equilibrium. There exist infinitely many possible conventions since the expectational mechanism is completely self-fulfilling within certain bounds. The conventional equilibrium can arbitrarily depend on almost any exogenous variable and in this sense it is a genuine *sunspot* equilibrium. On the other hand, it is also clear that some conventions make more sense than others. In this model the convention could be determined, for instance, by what the prevailing economic theory has to say about the relationship between money growth and output. That is the case we will consider here, neglecting all other possibly relevant variables such as last year's number of storks, today's weather forecast, etcetera — a neglect that can be justified by the fact that on evolutionary grounds we would anticipate these conventions to die out. We thus concentrate on conventions that determine the extent to which a change in the money supply will affect output, and to which it will affect prices.

This still leaves us with a large range of possible conventions, but it also follows from the model that not all conventions are possible. It is easily seen, by combining (12) with (5), that employment $l_t$ can never take a value above $l_t = -\zeta(w_t - p_t)$. Therefore, taking expectations and using (11) we find:

$$ {}_t y^e_{t+1} \leq -\zeta\theta(w_t - p_t) \tag{16} $$

From (16) it follows that there exists a "full employment ceiling" which every rational convention will have to take into account. We can therefore write a convention in its most general form as:

$$ {}_t y^c_{t+1} = Min\{C_t, S_t\} \tag{17} $$

where

$$ C_t = -\zeta\theta(w_t - p_t), $$

the "full employment ceiling", and:

$$ S_t = S(m_t, {}_{t-1}m^e_t), $$

the "sunspot variable" which we assume to depend on the money stock.

Now, for reasons of analytical convenience, we will just consider two simple conventions, which in some sense form the two extreme cases in this range of rational conventions. As mentioned above, these conventions are linked to the conventions on the labour market which determine the adjustment speed of nominal wages.

The simplest possible convention is then:

$$ {}_t y^e_{t+1} = C_t \tag{18} $$

with the corresponding wage equation:

$$w_t = {}_{t-1}\, p_t^e \tag{19}$$

This convention excludes the possibility of less-than-full-output: agents believe that the labour market always clears at a unique real wage level, and as a consequence the labour market always clears at this level and output has a unique natural level. This would be the unique rational expectation in the model of section 2.1; hence, just as in that model, output is only affected by unexpected changes in the real wage. It can easily be checked that if this "Lucas" (L) view of the world prevails, the model is effectively identical to the one from section 2.1; hence, the economy behaves in exactly the same way as in the standard Lucas supply model in that only unexpected changes in the rate of money supply can push the economy away from its unique natural rate equilibrium. All expected changes in money supply just affect prices.

If, however, it is believed for whatever reason that there is a role for monetary policy and that output may not have a unique natural rate level, then expectations could reasonably be formed according to:

$${}_t y_{t+1}^e = Min\left\{C_t, (y_t + c({}_t\hat{m}_{t+1}^c - \hat{m}_t))\right\} \tag{20}$$

where $\hat{m}_t = m_t - m_{t-1}$, the percentage increase in nominal money, and ${}_t\hat{m}_{t+1}^c = {}_t m_{t+1}^c - m_t$, expected money growth; $c$ is a constant.

The corresponding wage equation is:

$$w_t = \frac{1}{\eta\theta} y_t + {}_{t-1}p_t^e \tag{21}$$

The shape of equation (20) still leaves us with a large range of possible conventions; in fact, if c equals zero we again recover the L convention. Hence, we specify:

$c = 0$ if $({}_t\hat{m}_{t+1}^c - \hat{m}_t) > 0$;

$c = 1$ if $({}_t\hat{m}_{t+1}^e - \hat{m}_t) \leq 0$.

This "De Long & Summers" (DS) convention in effect represents the other extreme in the spectrum of possible conventions; a decrease in the anticipated growth rate of the money supply is expected only to affect output, and leave prices unchanged. Moreover, this immediately leads to the establishment of a new natural rate of output, because the asymmetric effect of demand shocks gives rise to a "hysteresis" effect that makes a return to the old natural rate impossible. This may perhaps seem non-rational from a collective point of view, but for the individual enterpreneur it can be completely rational. If one expects others to form their expectations according to the DS paradigm, aggregate demand may be expected to fall permanently in reaction to a decrease in money growth.

Therefore, it is optimal to act in the same way as others and to reduce one's demand for labour permanently.

It could of course be argued that the DS convention does not offer a realistic description of the way economic agents form expectations about the effect of monetary policy, but the same argument can be put against the L convention which provides the basis for the standard "Lucas supply" model. The model with the DS convention has the advantage that it does not contradict several well-known empirical phenomena, such as the fact that real wages do not behave countercyclically during recessions, and that unemployment is "sticky" and its response to shocks asymmetric[13]. Moreover, we will argue in section 4 that the DS version of the model performs better in explaining real world disinflation experiences than does the Lucas supply model.

Our first aim remains however to show that a change in convention can entirely change the role of credibility in the same model of monetary policy. To that end, we will now consider the role of credibility and precommitment in relation to a disinflationary policy under the L and the DS convention, respectively.

# 3 Disinflation policy under alternative conventions.

## 3.1 The L Convention

Consider the simple case of a disinflationary policy: the government seeks to reduce inflation by lowering the rate of money growth permanently. Suppose that before the initial period, $t_0$, all real variables are at their "full employment" natural rate level:

$$y_t = l_t = l_t^d = l_t^s = 0 \text{ for all } t < t_0;\ y_0 = 0.$$

Assume in addition that at $t_0$, when the government's planning period starts, the rate of inflation and money growth are positive. Assume that

$$m_0 = 0, \text{ hence } p_0 = w_0 = 0, \text{ but let } \pi_0 = p_0 - p_{-1} = \hat{m}_0 = A > 0.$$

Finally assume that the policymaker's current period loss function is still given by equation (9).

The optimal rate of money growth under the L convention will be independent from the "inherited" rate of inflation $A$, since the model under this convention is clearly equivalent to the BG model. We already saw that if the policymaker has full credibility (perhaps because a form of external commitment is possible) the optimal rate of inflation and money growth will then equal zero. Hence, the implemented strategy will be:

[13] As summarized by Hamermesh (1991): "the dynamic behaviour of employment is asymmetric: adjustment is less rapid in response to positive shocks and when unemployment is lower".

$m_t =_{t-1} m_t^e =_{t-1} \hat{m}_t^e = \hat{m}_t = \pi_t = 0$ for all $t > t_0$.

There will be no effect on output: $y_t = 0$ for all t. Therefore $z_t = 0$ for all $t > t_0$.

If instead no precommitment is possible, and the policy takes place under discretion with the private sector fully aware of the government's objectives, then the implemented strategy will be:

$_{t-1}\hat{m}_t^e = \hat{m}_t = \pi_t = \zeta\theta\xi/2$ for all $t > t_0$. Again, there will be no effect on output.

Under discretion, a disinflation will thus take place if and only if $A > \zeta\theta\xi/2$. Moreover, this disinflation will be incomplete and occur without any cost to output.

## 3.2 The DS convention with precommitment

We will now compare disinflation policy under the L convention with the same policy under the DS convention. In order to focus on the role of credibility, we will assume that under the DS convention the government implements the zero-inflation strategy that is optimal under the L convention. As we will see later, there are basically two cases in which the government will implement this policy:

- The government is unaware of the fact that the DS convention prevails and accordingly precommits itself to the optimal zero-inflation policy of the alternative (L) convention.
- Initial inflation is not "too low", so that a zero-inflation policy is the optimal policy for the DS convention under discretion.

The first case is obvious: since expectations are formed according to a "private sector convention" the government may not be aware of this convention and mistakenly commit itself to the optimal policy under the alternative convention. With precommitment, such a choice will be perfectly credible.

The second case will be derived in the next section, where we will show that a zero-money-growth policy is the optimal policy for a wide range of initial situations under common knowledge of the DS convention. That is, if the DS convention prevails, if the government knows that this convention prevails, if the private sector knows that the government knows this, and the government knows that the private sector knows etc. etc. ..., then a zero-inflation policy will be optimal and credible. However, it is not clear that such common knowledge should prevail. It is perfectly possible that the government believes in the DS convention and announces a zero-inflation policy while in fact the L-convention prevails among private agents. In this situation, the announced zero-inflation policy will clearly lack credibility since the private sector will expect the government of cheating. So even though there is no incomplete information in the usual sense since the private

sector has complete information on the government's objectives, there is still a credibility problem since beliefs may be mutually inconsistent. This problem will disappear once a zero-inflation policy has been implemented under the DS convention: in the periods following a period of zero-money-growth, it will *always* be optimal to stick to a zero-inflation policy, independent of the conventional beliefs of both private sector and government. We will therefore consider the following two cases:

1. A fully credible zero-money-growth policy; this policy is implemented under discretion if there is common knowledge of the DS convention, and under precommitment if the government mistakenly beliefs the L convention prevails.

2. A zero-money-growth policy without credibility in the first period of implementation; this policy is implemented under discretion if the government correctly believes that the DS convention prevails while the private sector thinks the government believes in the L convention instead.

Table 2 gives the effects of the first policy, a fully credible complete disinflation such that:

$$m_t =_{t-1} m_t^e =_{t-1} \hat{m}_t^e = \hat{m}_t = 0 \text{ for all } t \geq t_1$$

| **DS: Zero-inflation Policy under Precommitment** | | | | | |
|---|---|---|---|---|---|
| *Variable* | *Period* | | | | |
| var | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_T$ |
| $\hat{m}_t$ | $A$ | 0 | 0 | 0 | 0 |
| $w_t$ | 0 | $A - A/\theta\eta$ | $A - A/\theta\eta$ | $A - A/\theta\eta$ | $A - A/\theta\eta$ |
| $l_t$ | $-A/\theta$ | $-A/\theta$ | $-A/\theta$ | $-A/\theta$ | $-A/\theta$ |
| $y_t$ | 0 | $-A$ | $-A$ | $-A$ | $-A$ |
| $p_t$ | 0 | $A$ | $A$ | $A$ | $A$ |
| $\pi_t$ | $A$ | $A$ | 0 | 0 | 0 |
| $z_t$ | $A^2$ | $A^2 + \xi A$ | $\xi A$ | $\xi A$ | $\xi A$ |

Table 2: The effect of a credible disinflation

The fully believed announcement, at $t_0$, that future money growth will be zero, immediately affects expectations of future production, and therefore lowers employment. As a consequence, production is lower at $t_1$, leaving inflation unaltered. This negative effect on production is not temporary: if the government sticks to the pre-announced policy, expectations of future production determined by equation (20) will be constant at the new level $(-A)$ and therefore labour demand and output will also be permanently lower. This fall in output moreover provokes a simultaneous drop in the real wage and hence in labour

supply, since equation (21) ensures labour-market clearing under perfect foresight. This is shown in figure 2: the shift in labour demand from $l^d_{-1}$ to $l^d_0$ gives a new market-clearing real wage of $w_t - p_t = -A/\theta\eta$.

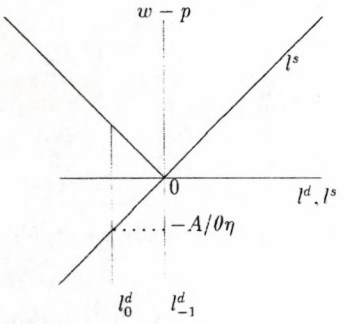



Figure 2: The effects of a credible disinflation on the labour market

We conclude that although the government policy eventually succeeds in bringing inflation down, it burdens the economy with a permanent cost since the self-fulfilling nature of expectations establishes a new suboptimal natural rate of output.

## 3.3 The DS convention without initial credibility

We now want to compare the results above with those of the second policy. The question is therefore what happens if the announced zero-inflation policy is not credible initially, that is, if money growth expectation are constant in period $t_0$ ($_0\hat{m}_1 = A$), but adapt after the first period of implementation ($_{t-1}\hat{m}^e_t = 0$ for all $t > t_1$) ? The results in this case are shown in table 3. The effects initially correspond to those of an unexpected disinflation under the L convention: there is a negative effect on output since the real wage is subject to an upward shock due to the unexpected fall in money growth. However, under the DS convention this effect becomes permanent due to the *hysteresis* mechanism present in the formation of expectations. After period $t_2$ the economy reaches a new natural rate equilibrium with market-clearing at a permanently lower level of output.

The costs of this policy clearly depend on the value of $\zeta\theta$. In the BG framework $\zeta\theta = 1$; if this is also the case here an unexpected disinflation will be slightly preferred to an expected one, given a discount factor smaller than one. However, it is not obvious that the BG situation is the most realistic one. It seems more in line with the mixed empirical evidence on the slope of the Phillips curve to assume $\zeta\theta < 1$, so that a one-percent change in the rate of inflation has a less than proportional effect on output. In

| DS: A Zero-inflation Policy under Discretion | | | | | |
|---|---|---|---|---|---|
| *Variable* | *Period* | | | | |
| var | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_T$ |
| $\tilde{m}_t$ | $A$ | 0 | 0 | 0 | 0 |
| $w_t$ | 0 | $A$ | $(\theta - \frac{1}{\eta})\zeta A$ | $(\theta - \frac{1}{\eta})\zeta A$ | $(\theta - \frac{1}{\eta})\zeta A$ |
| $l_t$ | 0 | $-\zeta A$ | $-\zeta A$ | $-\zeta A$ | $-\zeta A$ |
| $y_t$ | 0 | 0 | $-\zeta\theta A$ | $-\zeta\theta A$ | $-\zeta\theta A$ |
| $p_t$ | 0 | 0 | $\zeta\theta A$ | $\zeta\theta A$ | $\zeta\theta A$ |
| $\pi_t$ | $A$ | 0 | $\zeta\theta A$ | 0 | 0 |
| $z_t$ | $A^2$ | 0 | $A^2 + \zeta\theta\xi A$ | $\zeta\theta\xi A$ | $\zeta\theta\xi A$ |

Table 3: The effect of an initially non-credible disinflation

that case an unexpected disinflation would clearly be preferable to an expected one even without discounting, and the effect of credibility as usually defined, is counterproductive: the government is better off without a reputation for "toughness". We will assume $\zeta\theta < 1$ in the rest of the paper.

A precommitment to the *ex ante* optimal policy under the unique- equilibrium (L) convention, which equals the standard "zero inflation" optimal policy of the BG model, thus has counterproductive effects if the private sector's expectations are determined by another (DS) convention instead. Moreover, if this policy were to be implemented under discretion, the government is actually better-off if it is thought to possess mistaken beliefs! In this sense "credibility" is truly counterproductive under the DS convention.

# 4 Credible policy under the DS convention.

## 4.1 Calculating the optimal policy.

In the previous section it was stated that optimal money growth under discretion for the DS convention would equal zero in nearly all cases. We will now prove this statement and calculate the government's optimal policy under common knowledge of the DS convention, with and without precommitment. Doing so, we encounter an additional problem when compared with the standard model. In that model there was a unique natural rate of output and unemployment, hence the optimal policy, both *ex ante* and *ex post*, depended uniquely on the government's objectives. Now instead there is an infinite number of natural rates and the equilibrium of the economy is history-dependent. The optimal policy will be history-dependent as well, even if the economy is initially in equilibrium (so that the labour market clears and all expectations are fullfilled). The initial situation may

well be characterized by suboptimal inflation and output levels and the optimal policy consequently will depend on these levels.

Thus, we indicate the value for the "inherited" rate of inflation by:

$\pi_0 = \hat{m}_0 = A(A \geq 0)$; initial output is given by $y_0 = -B(B \geq 0)$.

Depending on its objectives, the government may or may not want to change this initial situation by changing the value of its policy instrument, $m_t$. Adapting the linear quadratic cost function from (9) and (10) to this policy instrument gives the following minimization problem:

$$\min_{m_{t,T}} L_t = \sum_{\tau=t}^{T} \lambda^{\tau}[\pi_{\tau}^2 - \xi y_{\tau}] \tag{22}$$

where $m_{t,T} = \{m\}_{\tau=t}^{T}$; $\xi \geq 0$, $0 < \lambda < 1$.

So, the monetary policymaker has to choose the path for $m_\tau$ which minimizes its discounted losses. It is easy to check that the monetary policymaker cannot raise output if the economy is in an equilibrium with a suboptimal level of production, such as that which results after period 2 in table 3; it makes no difference whether its policy announcement is credible or not. This is a consequence of the "hysteresis" mechanism implicit in the DS convention, caused by the assumption that there is no stockpiling of labour and capital so that firms always operate at full capacity. After a downward adjustment, the economy will be in a new, full market clearing, 'natural rate' equilibrium, where output and employment are permanently lower, and cannot be raised. This asymmetry in the effect of monetary policy implies that, like in the BG model, the only variable that the policymaker can effectively control is the rate of inflation. The initial value for $\hat{m}_0 (= \pi_0 = A)$ may be too high so that it is optimal to choose a lower rate of money growth, but unlike the BG model, an expected disinflation will be costly: reducing the rate of inflation will also reduce output permanently.

We proceed as follows: first, we derive the optimal policy under precommitment. Proposition 1 outlines the cases in which the government would want to disinflate, starting from an initial inflation rate of A, and derives the optimal rate of money growth under precommitment. Along the lines of the original discussion of the time inconsistency of monetary policy in BG, we then drop the assumption that precommitment is possible, and assume that the private sector is fully informed about the government's objectives. It is then proved, in proposition 2, that an ex ante optimal disinflation policy is always time inconsistent, and therefore credibility is an issue. Finally, in proposition 3, we show that under common knowledge of the DS convention the optimal credible rate of money growth under discretion equals zero in nearly all cases, and that the government will therefore be forced to implement precisely the zero-money growth policy discussed in the previous section, with the resulting negative effects on output and employment.

## 4.2 The optimal policy under precommitment.

First consider the effects of a disinflation policy under precommitment. It is assumed that:

$y_0 = -B, m_0 = -B$, hence $p_0 = 0$, but: $\pi_0 = p_0 - p_{-1} = \hat{m}_0 = A \geq 0$.

The economy finds itself in a market clearing equilibrium, with the real wage at a new natural rate level $w_0 - p_0 = -B/\eta\theta$. For all $t \geq t_1$ the government implements $\hat{m}_t = \pi^*(0 \leq \pi^* \leq A)$. Because of the precommitment, this policy is fully credible: ${}_{t-1}\hat{m}_t^e = \pi^*$ for all $t \geq t_1$.

The results are summarized in Table 4, where $\Gamma = B + (A - \pi^*)$ and all other symbols are defined as before. This table thus represents a generalized version of table 2, showing the effects of a disinflation policy under precommitment. The results are therefore very similar: the expected drop in money growth first lowers labour demand, then output and finally prices. The fall in output is permanent due to the "hysteresis" mechanism in the formation of expectations, and hence there will be a new, suboptimal, natural rate level of output and employment.

| **DS: Partial Disinflation under Precommitment** | | | | | |
|---|---|---|---|---|---|
| *Variable* | *Period* | | | | |
| | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_T$ |
| $l_t$ | $-\Gamma/\theta$ | $-\Gamma/\theta$ | $-\Gamma/\theta$ | $-\Gamma/\theta$ | $-\Gamma/\theta$ |
| $y_t$ | $-B$ | $-\Gamma$ | $-\Gamma$ | $-\Gamma$ | $-\Gamma$ |
| $p_t$ | 0 | $A$ | $A + \pi^*$ | $A + 2\pi^*$ | $A + (T-1)\pi^*$ |
| $\pi_t$ | $A$ | $A$ | $\pi^*$ | $\pi^*$ | $\pi^*$ |
| $z_t$ | $A^2 + \xi B$ | $A^2 + \xi\Gamma$ | $\pi^{*2} + \xi\Gamma$ | $\pi^{*2} + \xi\Gamma$ | $\pi^{*2} + \xi\Gamma$ |

Table 4: The effect of a partial disinflation under commitment

We can now state the first proposition[14]:

PROPOSITION 1: Suppose that the DS convention applies, that the initial rate of inflation equals $\pi_0 = A(A \geq 0)$ and that the government's loss function is given by (22). Then the optimal policy under precommitment equals $\hat{m}_t = \pi^* = Min\{A, \xi/2\lambda\}$ for all $t \geq t_1$.

So under the DS convention a disinflation will only take place if the initial rate of inflation is not too low, because in that case the cost reduction due to lower inflation will not compensate for the losses in output which result from this policy. It is interesting to

[14]The proofs of all propositions are provided in the Appendix.

compare the *ex ante* optimal (precommitment) solution under the DS convention to the third-best (no commitment) solution under the L convention. As was seen in section 2.1, the optimal rate of money growth and inflation in the latter case equalled $\hat{m}_t = \pi_t = \zeta\theta\xi/2$ for all t. Since $0 < \lambda < 1$ and $\zeta\theta < 1$, the government, under the DS convention, would like to precommit itself to an inflation rate which lies above this value.[15] This is illustrated in figure 3.

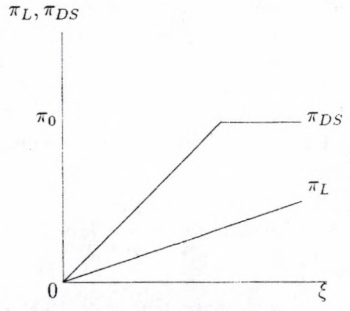



Figure 3: Optimal Inflation rates under Alternative Conventions

The kinked line $\pi_{DS}$ in this figure shows the optimal inflation rate under the DS convention when the government can commit itself: only if the initial inflation rate $\pi_0$ is "too high" relative to the government's preference variable $\xi$ is a disinflationary policy optimal. Line $\pi_L$ shows the optimal policy under the L convention when commitment is not possible: as seen before, this policy is independent of history. Since the optimal policy under the DS convention is the result of a largely arbitrary expectation of future production, one should not attach to much weight to the relationship between the two outcomes: it is largely arbitrary as well. Still, it is worth noting that, due to the pessimistic nature of the DS convention, the ex ante optimal policy under this convention will leave the government generally worse-off than if it were to implement a suboptimal (Nash-) policy under the L convention.

## 4.3 The optimal policy under discretion.

We have analyzed the optimal monetary policy under the DS convention assuming that the policymaker could precommit itself. If this is not possible, will this policy still be credible?

[15] In BG this suboptimal inflation rate equals $\pi = b/a$. Rewritten in terms of the model of this paper, this is precisely $\pi = \xi/2$.

In answering this question, we maintain our previous assumptions: the private sector has complete information about the government's objectives and the planning period extends over a large but finite number of periods.

In the previous section we saw that an unexpected implementation of a zero money growth policy under the DS convention has less negative effects on output than a fully credible disinflation. Can we extend these results to the kind of "partial disinflation" considered in the previous subsection? In other words, is there an incentive to disinflate unexpectedly, that is, to implement a rate of money growth that lies below the ex ante optimal rate under the DS convention? Table 5 gives the results of what happens if the private sector initially expects a disinflation with the government setting $\hat{m}_t = \pi^*$ for all $t \geq t_1$, whereas the government instead sets $\hat{m}_t = \pi^\circ$ for all $t \geq t_1$, $\pi^\circ < \pi^*$. Again, it is assumed that the private sector adapts its expectations so that ${}_{t-1}\hat{m}_t^e = \pi^\circ$ for all $t \geq t_2$. We define: $\Lambda = (A - \pi^*)$; all other symbols defined as before.

| **DS: Partial Disinflation under Discretion** | | | | |
|---|---|---|---|---|
| *Variable* | *Period* | | | |
| | $t_0$ | $t_1$ | $t_2$ | $t_T$ |
| $l_t$ | $-\Gamma/\theta$ | $-\Gamma/\theta$ | $-\Gamma/\theta$ | $-\Gamma/\theta$ |
| $y_t$ | $-B$ | $-\Gamma$ | $-\Gamma$ | $-\Gamma$ |
| $p_t$ | 0 | $\pi^\circ + \Lambda$ | $2\pi^\circ + \Lambda$ | $T\pi^\circ + \Lambda$ |
| $\pi_t$ | $A$ | $\pi^\circ + \Lambda$ | $\pi^\circ$ | $\pi^\circ$ |
| $z_t$ | $A^2 + \xi B$ | $(\pi^\circ + \Lambda)^2 + \xi\Gamma$ | $\pi^{\circ 2} + \xi\Gamma$ | $\pi^{\circ 2} + \xi\Gamma$ |

Table 5: The effect of a partial disinflation under discretion

This table suggests that if the government were able to reduce the inflation level unexpectedly, this could occur without any costs to output: the level of output equals $-\Gamma$ for $t \geq t_1$, the same value as in table 4. However, this does not mean that the optimal (unexpected) level of money growth equals zero: the crucial assumption underlying Table 5 that the unexpected reduction in money growth does not push real wages "too high", so that the demand for labour, and hence production, is determined by the "real wage ceiling" ($C_t$) of equation (20) and not by the "sunspot" variable ($S_t$) in the same equation. Formally, this requires that $C_t \leq S_t$; hence:

$$(-B + \pi^* - A)/\theta \leq (\zeta/\eta\theta)B + \zeta(\pi^\circ - \pi^*)$$

It then follows that unexpected money growth should not be too low:

$$\pi^\circ \geq \frac{(1 + \zeta\theta)\pi^* - A - (1 + \zeta/\eta)B}{\zeta\theta} \tag{23}$$

It is easy to see that if $\pi^e = \pi^* = A$ and $B = 0$ it follows that $\pi^\circ \geq A$. Table 3 thus provides an example of a case in which (23) does not hold: the unexpected increase in real wages immediately had a negative effect on employment and production. This is illustrated in figure 4: the labour demand curve shifts backwards because of the unexpected rise in real wages, shifting the equilibrium to the left as well.

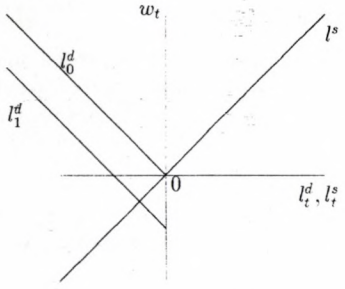



Figure 4: The effects of an unexpected disinflation on the labour market

We can now derive the following proposition:

PROPOSITION 2: Suppose that the DS convention is common knowledge, that the initial rate of inflation is $\pi_0 = A (A > 0)$ and that the government's loss function is given by (22). Then the *ex ante* optimal rate of inflation $\pi_t = \pi^*$ for all $t \geq t_1$ will not be credible under discretion for $\pi^* < A$.

Therefore no *ex ante* optimal disinflation will be credible under the DS convention. This does not imply that *any* ex ante optimal policy is time inconsistent, since it is still possible that under discretion the government would want to stick to the initial rate of inflation $\pi_0 = A$ in cases where the private sector expects it to do so. In other words, it may be that the horizontal part of the $\pi_{DS}$-line in figure 3 is credible under discretion, since the government has no incentive to surprise the private sector with an unexpected disinflation. To see this, we first have to consider the case of a larger disinflation than allowed for in (23), so that:

$$(-B + \pi^* - A)/\theta > \frac{\zeta}{\eta\theta} B + \zeta(\pi^\circ - \pi^*)$$

This means that output and unemployment are determined by the "real wage ceiling"

$C_t$ so that the values for $y_t$ and $p_t$ in table 5 have to be replaced by:

$$y_t = \Omega = \frac{\zeta}{\eta} B + \zeta\theta(\pi^\circ - \pi^*) \text{ and } \pi_t = \pi^\circ, \text{ for all } t \geq t_2;$$

whereas the values for $t \leq t_1$ are the same as those shown in the table.

We can now state the following corollary[16]:

COROLLARY 1: Suppose that the DS convention applies, that the initial rate of inflation is $\pi_0 = A (A > 0)$, that the government's loss function is given by (22), and that the private sector's expectation of money growth equals ${}_0\hat{m}_t^e = \pi^* = A$. Then the government will have an incentive for a "large" disinflation so that (23) no longer holds, setting $\hat{m}_t = \pi^\circ < \pi^*$ for all $t \geq t_1$ if and only if $A > \lambda\zeta\theta\xi/2$.

This confirms the intuitive notion that the initial rate of inflation A should be high enough in order to make a costly disinflation profitable. We can now derive the following proposition:

PROPOSITION 3: Suppose that the DS convention is common knowledge, that the initial rate of inflation $\pi_0 = A\ (A > 0)$ and the initial level of output $y_0 = -B\ (B \geq 0)$, and that the government's loss function, given by (22), is known to the private sector. Then the uniquely credible, subgame perfect, rate of money growth equals $\hat{m}_t = A$ for $A < \frac{\lambda\zeta\theta\xi}{2}$ and $B = 0$, and $\hat{m}_t = 0$ for all other cases, for all $t \geq t_1$.

In an economy where the DS convention prevails, the government will thus be forced to disinflate completely in nearly all circumstances, the only exception being a situation in which output is maximal ($B = 0$) and inflation is low ($A < \frac{\lambda\theta\zeta\xi}{2}$). At first glance, this result is paradoxical: for certain parameter values, the government may want to disinflate, but only if this can be done unexpectedly. From Table 4 it follows that a fully expected zero-inflation policy will only be welfare-improving if:

$$\sum_{\tau=1}^{T} \lambda^\tau[\xi(A+B)] + \lambda A^2 < \sum_{\tau=1}^{T} \lambda^\tau[A^2 + \xi B]$$

This condition is fulfilled if $A > \xi/2\lambda$ , independently of the value of $B$. But from above it follows that a full disinflation may also take place if this condition is not fulfilled, so that this policy actually decreases current government welfare. The explanation is that if the government were not to disinflate, the effect of the private sector's expectations on welfare would be even more negative[17]: the government therefore has to accomodate its monetary policy to the private sector's expectations.

[16]The proof can be found in the Appendix

[17]As shown in the Appendix, in the second part of the proof of proposition 3

## 4.4 A discussion of the results.

This section closely followed the procedure of the BG paper: the optimal policy rule under commitment was shown to be generally time inconsistent in a model with a finite number of periods; and in consequence the unique credible, subgame perfect policy under perfect information may be viewed as suboptimal. However, although the procedure was comparable, the two different models produce almost exactly opposite policy prescriptions: under the L convention, the policymaker would like to commit to a zero inflation rate but is forced to inflate instead when credibility is lacking; under the DS convention the policymaker would like to commit itself to an inflation rate above zero but is forced to implement a costly disinflation. Thus, before choosing its policy plan, the government must be aware of the convention which prevails in society; moreover, it must have the certainty that this convention will not change halfway during the planning period since a commitment to the wrong policy could be very costly.

Does the DS version of the model offer a realistic description of real-world disinflation experiences? It does seem clear that the results of this section can explain a number of empirical phenomena that contradict the Lucas supply theory. It explains why credible disinflation policies, carried out by conservative governments, could still be extremely costly in terms of loss in output and unemployment. It also explains why a government would want to implement such a policy in the first place: the costs of not doing so would have been even larger. And finally it explains why stabilization policies may have *permanent* effects on output and unemployment: in other words, it allows us to understand the *hysteresis* phenomena which characterized the behaviour of unemployment after the disinflation experiences of most West-European countries in the early 1980.

However, it is also clear that the model has several shortcomings. It does not explain why conventions should change, and it seems rather simplistic to attribute recent disinflation experiences to an arbitrary change in the degree of pessisimism of private agents. Part of this criticism could be met by introducing stochastic shocks into the model. If these were incompletely predictable, the government would generally overaccommodate in order to avoid the permanent effects on output that negative shocks produce under the DS convention. This, in turn, would cause an inflationary bias - but only temporarily: once the inflation level would exceed a certain level, or once output would be affected, the government would be forced to implement a costly disinflation even without an arbitrary change in convention.

There are also other ways in which the analysis of this section could be extended. It is interesting to see what effects the modifications of the standard monetary policy game would produce under the DS convention. Following BG, a first step would be to include reputational effects by allowing the private sector to play trigger strategies in an infinite horizon framework. However, a fundamental problem would arise: would changes in convention be reflected in changes in trigger strategies, or not? In some sense, anything

could happen: the multiplicity of (trigger strategy) equilibria which resulted from the BG framework would be combined with an infinite number of possible conventions. Second, one could allow for asymmetric information, as in Backus and Driffill (1985), Cuckierman and Meltzer (1986), and Basar and Salmon (1990). But under the DS convention, the issue of the type of a policymaker is less important as many types would be indistinguishable anyway. For example, both Backus and Driffill's "hard-nosed" and "soft-nosed" policymakers would generally implement a zero inflation strategy under discretion. Note moreover that even in cases where a distinction is possible the "tough" policymaker would prefer not to be credible and to be considered "soft", since an unexpected disinflation affects prices sooner than an expected disinflation.

It should be remembered that the DS convention discussed in this section is just one possible modification of the standard model. It is of particular interest, because its results are so fundamentally different — and because this difference is caused by a simple variation on the standard model. But other variations are possible. A logical first step would be to set $c = 1$ in equation (20), effectively lifting the "hysteresis" phenomenon from the expectation formation process. The permanent effect of stabilization policy on unemployment depends entirely on the pessimistic nature of the DS convention; and in effect we observe that several countries outside Western Europe, notably the US, did not witness such a permanent effect on unemployment even though they suffered similar "disinflation recessions" during the early 1980s. The model under consideration is thus capable of explaining differences in behaviour between economies by allowing for differences in conventions.

At this point one could object that absolutely anything could be explained by introducing arbitrary conventions. This is only partially true. In reality conventions do exist, they differ between different groups, and usually they are not arbitrary. Economic agents do find ways of coordinating their actions. Firms use pricing rules, unions stick to certain principles in wage negotiations, and do so on sensible grounds. Different societies may have different rules. Conventions may change over time, and even more significantly, these changes may be brought about by the economic policy implemented by the government[18]. For example, private agents quickly change their conventional behaviour under hyperinflations: wages are first indexed yearly, then monthly, then weekly, etcetera. Less extreme economic policies, such as those that generate a moderate level of inflation, may affect this conventional structure much more slowly; nevertheless, it would be a mistake for any economic planner to take the stability of beliefs, conventions, and ultimately institutions, for granted.

[18]The interaction between the evolution of private sector conventions and government credibility is analyzed in Hasekamp (1992).

# 5 Conclusions.

The objective of this paper has been in some sense to warn against the use of oversimplified models of economic policymaking. The primary aim has been to show that the standard BG framework of monetary policy gives a misleadingly simple impression as regards to the role of *credibility* in relation to economic policy. To this end, we modified the BG model by implicitly allowing for capital investment, and showed that then the standard "Lucas supply" structure can be considered a special case, the outcome of just one out of many possible conventions that serve to coordinate the expectations of atomistic private agents. It was seen that if another "opposing" convention is in force, both the *ex ante* and *ex post* optimal policy will be different in equilibrium. A "tough" reputation, that is a perceived commitment to zero-inflation, is counterproductive if this alternative convention prevails.

This simple example makes clear that credibility, in itself, is not sufficient as a means of solving the time-inconsistency problem if the private sector does not have a unique rational expectation. Hence the warning: before committing itself, the government must know what its ex ante optimal policy is — and, in general, this may be anything, depending on the convention which the private sector uses to coordinate its expectations.

The second aim of the paper was to offer an alternative model of disinflation policy. It has been argued that this alternative model succeeds in explaining several empirical facts which contradict the Lucas supply thesis, and that it does so without relying on arbitrary assumptions of nominal wage rigidity and staggered contracts[19]. Moreover, local variations in "pricing" conventions may help to explain differences in disinflation experiences between countries.

[19]The model is however capable of dealing with these phenomena as well. As noted in section 2, the fact that the expected market-clearing wage depends on the pricing convention in force creates a "moral hazard" problem: producers could try to lower nominal wages by overstating their pessimism. This in turn could prevent nominal wages from adapting quickly to new market-clearing levels: this new level will have to gain credibility first. Thus, even though the model does not need sticky wages in order to explain recessions, it can easily be adapted in order to include a degree of 'stickiness' which seems to fit reality and helps to explain prolonged spells of involuntary unemployment.

# A Mathematical Appendix

PROOF PROPOSITION 1: The government will only set $\hat{m}_t = \pi^* < A$ if the discounted costs of this disinflationary policy under precommitment are less than the costs of remaining in the initial equilibrium.

From (22) and table 4 it then follows that this requires:

$$\lambda A^2 + \xi\lambda\Gamma + \sum_{\tau=2}^{T} \lambda^\tau[\pi^{*2} + \xi\Gamma] < \sum_{\tau=1}^{T} \lambda^\tau[A^2 + \xi B]$$

Substituting $B + A - \pi^* = \Gamma$ and rearranging gives $\xi(A - \pi^*) < \lambda(A^2 - \pi^{*2})$. The government minimizes its loss function (22) by choosing a value for money growth $\hat{m}_t = \pi^*$ $(t \geq t_1)$ that maximizes this difference with the costs in the original situation. Therefore:

$$\max_{\pi^*}\{\lambda(A^2 - \pi^{*2}) - \xi(A - \pi^*)\}$$

Given that $0 \leq \pi^* \leq A$, it follows that $\pi^* = \frac{\xi}{2\lambda}$ for $A > \frac{\xi}{2\lambda}$ and $\pi^* = A$ otherwise. This concludes the proof □

PROOF PROPOSITION 2: From (22) and Table 5 it follows that the government will have an incentive to set its unexpected rate of inflation, $\pi^\circ$, as low as possible subject to the condition in (23). We can rewrite (23) as:

$$\pi^\circ \geq \pi^* - \frac{1}{\zeta\theta}(A - \pi^*) - ((1 + \zeta/\eta)/\zeta\theta)B$$

Since $B \geq 0$ and $0 < \pi^* < A$ in case of a disinflation, it follows that the lowest possible value for $\pi^\circ$ will equal $\pi^*$ if and only if $\pi^* = A$ *and* $B = 0$. For all $\pi^* < A$ there exists a $\pi^\circ < \pi^*$, such that the government will set $\pi^\circ$ when the private sector expects $\pi^*$. Since the private sector knows the government's objective function, the *ex ante* optimal rate of inflation $\pi^*$ will then not be credible. This concludes the proof. □

PROOF COROLLARY 1: It follows from (22) and table 5 that in general the government will have an incentive for a large disinflation — so that (23) no longer holds — if the costs of such a policy are lower than those for the lowest possible value of money growth given that (23) holds. Therefore:

$$\lambda(A + \pi' - \pi^*)^2 + \sum_{\tau=2}^{T} \lambda^\tau[\pi'^2 + \xi\Gamma] > \lambda(A + \pi'' - \pi^*)^2 + \sum_{\tau=2}^{T} \lambda^\tau[(\pi^\circ)^2 - \xi\Omega]$$

where $\pi'$ indicates the optimal rate of inflation given (23), and $\pi''$ is the (lower) optimal rate of inflation if (23) no longer holds. Assuming $T$ is large so that $\sum_{\tau=0}^{T} \lambda^\tau \simeq \frac{1}{1-\lambda}$ we obtain after some rearranging:

$$2(A - \pi^*)(\pi' - \pi'') + \frac{1}{1-\lambda}((\pi')^2 - (\pi'')^2) + \frac{\xi\lambda}{(1-\lambda)}[\Gamma + \Omega] > 0$$

Now consider the boundary case in which $\pi^* = \pi' = A$ (therefore $B = 0$ and $A < \xi/2\lambda$). Substituting the expressions for $\Omega$ and $\Gamma$ and rearranging gives:

$$A^2 - (\pi'')^2 > \xi\lambda\zeta\theta(A - \pi'')$$

The question is whether a $\pi''$ exists such that this holds and $0 \leq \pi'' < A$. Solving the equation it follows that this is true when $\frac{\lambda\zeta\theta\xi}{2} < A$. This concludes the proof.

PROOF PROPOSITION 3: The proof is structured as follows: it will first be proved that $\hat{m}_t = A$ for $A < \frac{\lambda\zeta\theta\xi}{2}$ and $B = 0$, and $\hat{m}_t = 0$ in all other cases are the only credible rates of money growth for the government. Subsequently, it will be proved that these are also the optimal rates of money growth.

It follows from the proof of proposition 2 that the government will have an incentive to implement a rate of money growth $\hat{m}_t = \pi^\circ$ which is smaller than the expected rate ${}_{t-1}\hat{m}_t^e = \pi^*$ if $B > 0$, and/or if $0 < \pi^* < A$. Hence, in this case, the only credible rate of money growth if the private sector knows the government objectives (so that $\pi^* = \pi^\circ$) is $\hat{m}_t = 0$ for all $t \geq t_1$. If, instead, $\pi^* = A$ and $B = 0$, there are two possibilities: we know from Corollary 1 that if $A > \frac{\lambda\zeta\theta\xi}{2}$ there will exist a rate of money growth $\pi^\circ < A$ such that unexpected implementation of this rate is welfare-improving. Thus, if $A < \frac{\xi}{2\lambda}$ (from propositions 1 and 2 we know that this is the necessary condition for $\pi^* = A$) and $A > \frac{\zeta\theta\xi}{2}$ there will exist a $\pi^\circ < A$. But then if ${}_{t-1}\hat{m}_t^e = \pi^* = \pi^\circ$ it follows again from proposition 2 that the only credible rate of money growth equals zero in this case. Instead, if $A < \frac{\lambda\zeta\theta\xi}{2}$ the government will have no incentive to set money growth below its expected level: ${}_{t-1}\hat{m}_t^e = \pi^* = \hat{m}_t = \pi^\circ = A$. This concludes the first part of the proof.

Now, what is the optimal rate of money growth? It follows directly from above that the credible rate of money growth $\hat{m}_t = \pi^* = A$ is also the optimal rate if $A < \frac{\lambda\zeta\theta\xi}{2}$ and $B = 0$: there is no incentive to implement a lower rate of money growth. If $\hat{m}_t = \pi^* = 0$, would the government not prefer to implement a non-credible (higher) rate of money growth? The answer to this is a clear "no", as can be seen from the table which gives the outcome of a monetary policy in which the government implements $\hat{m}_t = \tilde{\pi}$ for all $t \geq t_1$ whereas the private sector expects $\hat{m}_t^e = 0$ for all $t \geq t_1$.

Comparing this table with table 2 (a fully expected full disinflation) it is easy to see that it is always preferable to set $\tilde{\pi} = 0$, so that actual money growth equals expected money growth. This concludes the proof □

| *Variable* | *Period* | | |
|---|---|---|---|
| | $t_0$ | $t_1$ | $t_n$ |
| $l_t$ | $-(B+A)/\theta$ | $-(B+A+\tilde{\pi})/\theta$ | $-(B+A+n\tilde{\pi})/\theta$ |
| $y_t$ | $-B$ | $-B-A$ | $-(B+A+\tilde{\pi})$ |
| $p_t$ | 0 | $A+\tilde{\pi}$ | $A+(2n-1)\tilde{\pi}$ |
| $\pi_t$ | $A$ | $A+\tilde{\pi}$ | $2\tilde{\pi}$ |
| $z_t$ | $A^2$ | $(\tilde{\pi}+A)^2$ | $(2\tilde{\pi})^2$ |
| | $+\xi B$ | $+\xi(A+B)$ | $+\xi(A+B+n\tilde{\pi})$ |

Table 6: The effect of a smaller-than-expected disinflation under discretion

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